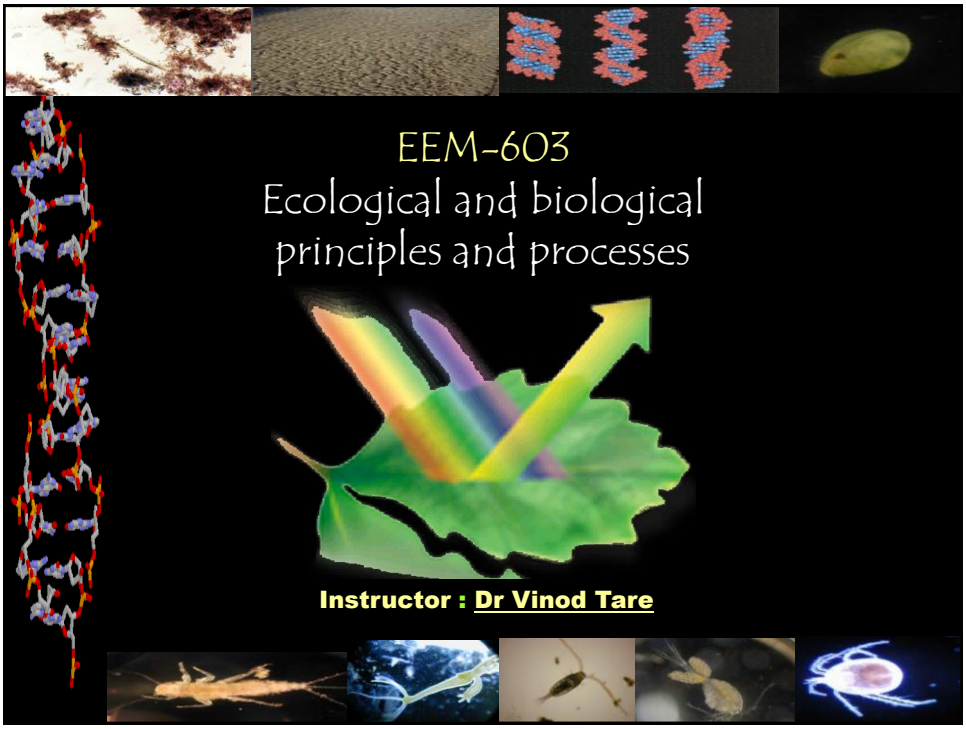


Course Content and Grading Policy

- Contents
  - Part I: Overview
  - Part II: Biochemistry
  - Part III: Microbiology
  - Part IV: Applications in Waste (Residue) Conversion/Processing
  - Ecology

- Grading Policy
  - Reading Material (PPT, Notes and Reference Material)
  - Study Questions
  - Quizes (Nine as per schedule): 20 % Weightage
  - Mid Semester Examination: 30 % Weightage
  - End Semester Examination: 50 % Weightage

Course Material

- www.iitk.ac.in/eem/eem603
  - Visit regularly for
    - Announcements
    - Quiz/Exam schedules
    - Lecture presentations
    - Course notes
    - Reference materials

References

- Weber, W J (2001) *Environmental Systems and Processes –Principles, Modeling and Design*, Wiley-Interscience, New York, USA.
- Botkin, D B and Keller, E A (1987) *Environmental Studies – Earth as a Living Planet*, 2nd Ed, Merril Publishing Company, Columbus, OH, USA.
- Turk J and Turk A (1988) *Environmental Science*, 4th Ed, Saunders College Publishing, Philadelphia, PA, USA.
- Caughley, G and Sinclair, A R E (1994) *Wildlife Ecology and Management*, Blackwell Scientific Publications, Boston, USA
- Pelzar, M J Jr, Chan, E C S and Krieg N R (1993) *Microbiology – Concepts and Applications*, McGraw Hill Inc, New York, USA.
- Benefield, L D and Randall, C W (1980) *Biological Processes Design for Wastewater Treatment*, Prentice Hall Inc, New Jersey, USA.
- Metcalf & Eddy, Inc. and Techobanoglous, G (1979) *Wastewater Engineering: Treatment, Disposal, Reuse*, McGraw Hill, New York, USA.

"Success is the ability to go from one failure to another with no loss of enthusiasm"

-Sir Winston Churchil

You @ IIT Kanpur



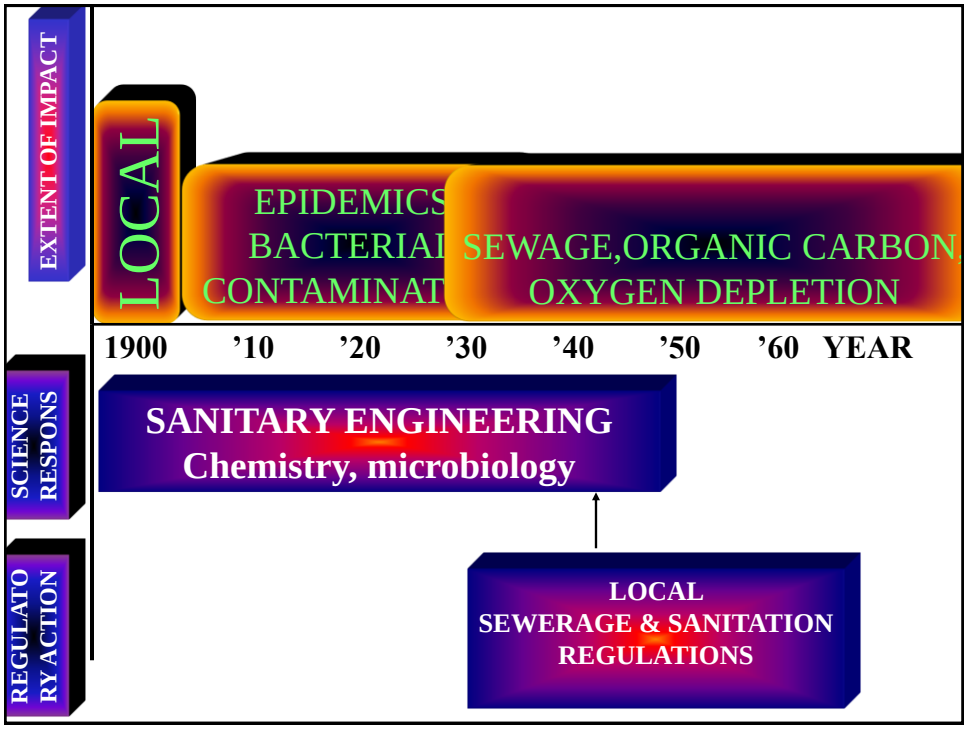


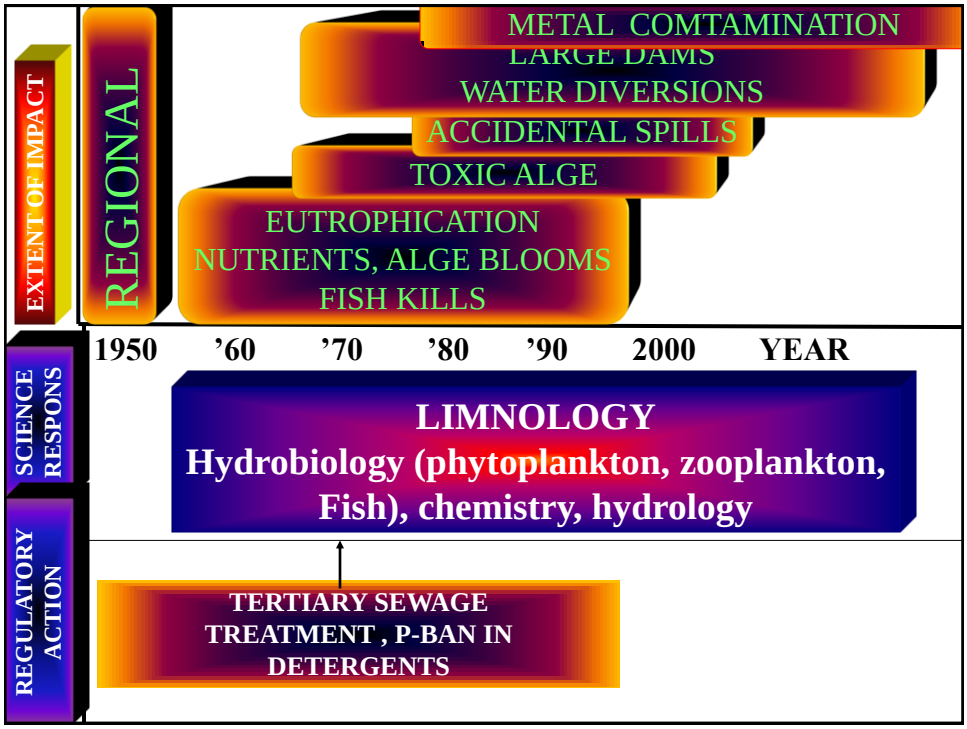

Emergence of Environmental Science/Engineering/Management Discipline

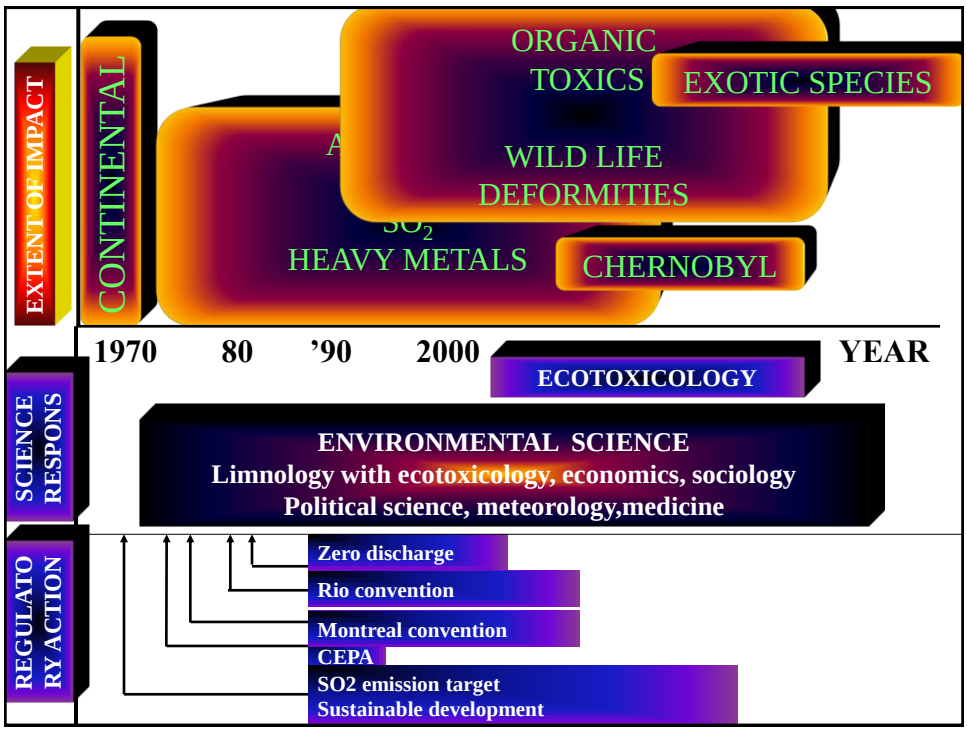
- **Public Health Engineering**
  - Water Supply → Civil Engineering
- **Sanitary Engineering**
  - Water Supply and Sanitation →Civil Engineering
- **Environmental Engineering and Management**
  - Inter Disciplinary → Infra-structural Engineering

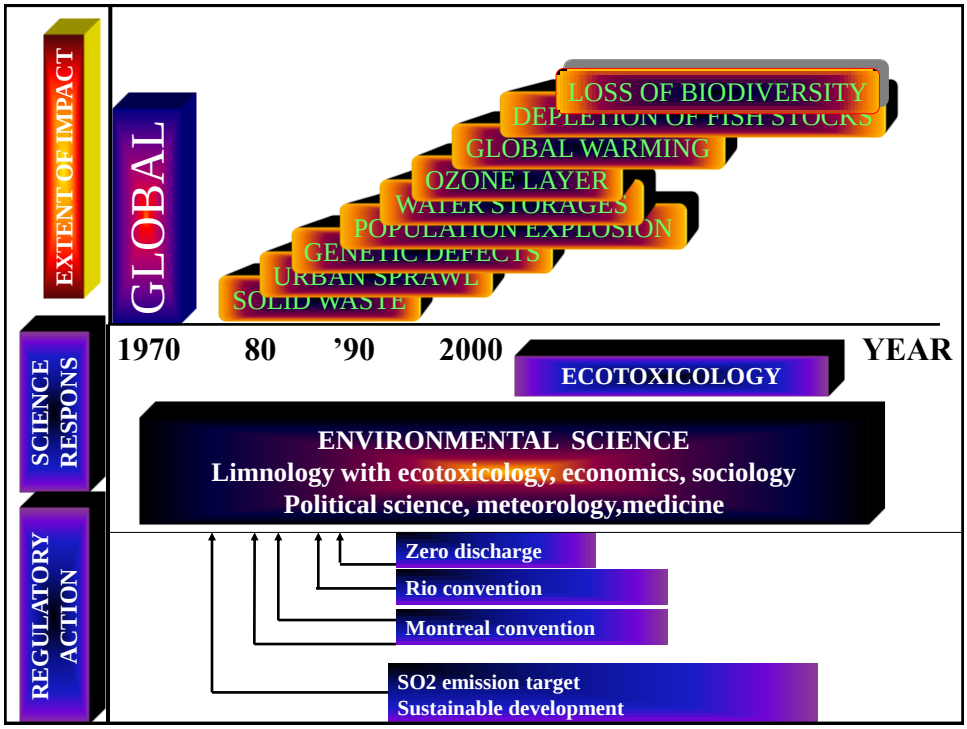
Explosion of Environmental Issues

- From Few to Many, From Local to Global
- Science Response
- Response of Regulatory Agencies




EXTENT OF IMPACT
REGIONAL
METAL COMTAMINATION
LARGE DAMS
WATER DIVERSIONS
ACCIDENTAL SPILLS
TOXIC ALGE
EUTROPHICATION
NUTRIENTS, ALGE BLOOMS
FISH KILLS
1950
'60
'70
'80
'90
2000
YEAR
SCIENCE RESPONS
LIMNOLOGY
Hydrobiology (phytoplankton, zooplankton, Fish), chemistry, hydrology
REGULATORY ACTION
TERTIARY SEWAGE TREATMENT , P-BAN IN DETERGENTS


EXTENT OF IMPACT
CONTINENTAL
ORGANIC TOXICS
EXOTIC SPECIES
WILD LIFE DEFORMITIES
SO_2
HEAVY METALS
CHERNOBYL
1970
80
'90
2000
YEAR
ECOTOXICOLOGY
SCIENCE RESPONS
ENVIRONMENTAL SCIENCE
Limnology with ecotoxicology, economics, sociology
Political science, meteorology,medicine
REGULATORY ACTION
Zero discharge
Rio convention
Montreal convention
CEPA
SO2 emission target
Sustainable development


EXTENT OF IMPACT
GLOBAL
LOSS OF BIODIVERSITY
DEPLETION OF FISH STOCKS
GLOBAL WARMING
OZONE LAYER
WATER STORAGES
POPULATION EXPLOSION
GENETIC DEFECTS
URBAN SPRAWL
SOLID WASTE
1970
80
'90
2000
YEAR
SCIENCE RESPONS
ECOTOXICOLOGY
ENVIRONMENTAL SCIENCE
Limnology with ecotoxicology, economics, sociology
Political science, meteorology,medicine
REGULATORY ACTION
Zero discharge
Rio convention
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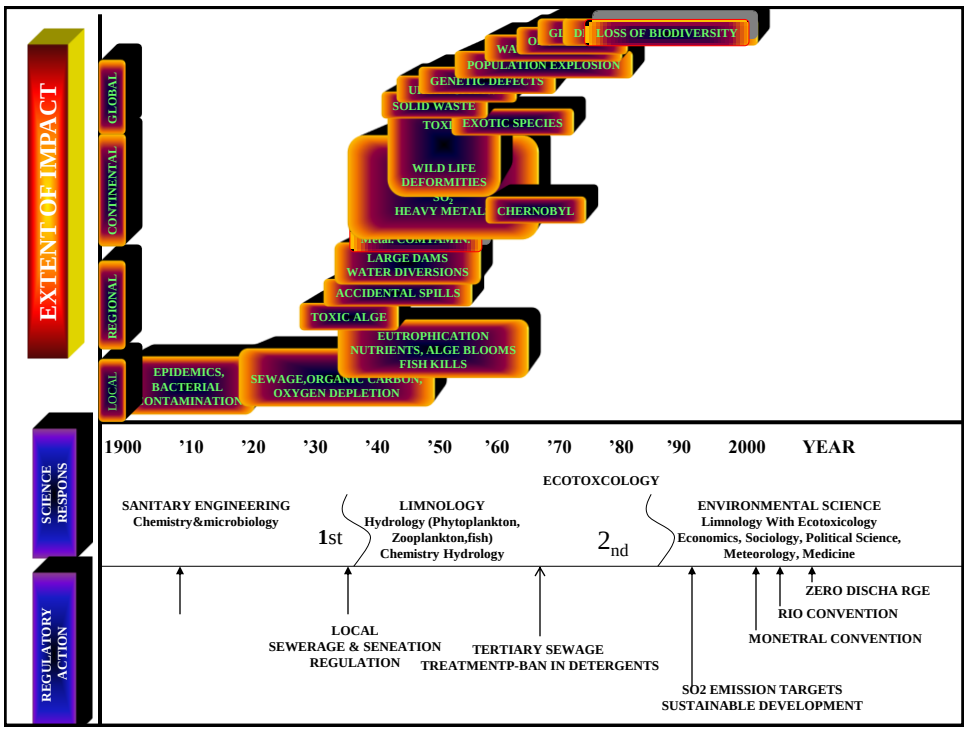
SO2 emission target
Sustainable development


EXTENT OF IMPACT
GLOBAL
CONTINENTAL
REGIONAL
LOCAL
LOSS OF BIODIVERSITY
POPULATION EXPLOSION
GENETIC DEFECTS
SOLID WASTE
EXOTIC SPECIES
WILD LIFE DEFORMITIES
HEAVY METAL
CHERNOBYL
LARGE DAMS
WATER DIVERSIONS
ACCIDENTAL SPILLS
TOXIC ALGE
EUTROPHICATION
NUTRIENTS, ALGE BLOOMS
FISH KILLS
EPIDEMICS, BACTERIAL
SEWAGE,ORGANIC CARBON,
OXYGEN DEPLETION
1900
'10
'20
'30
'40
'50
'60
'70
'80
'90
2000
YEAR
SCIENCE RESPONS
ECOTOXCOLOGY
SANITARY ENGINEERING
Chemistry&microbiology
1st
LIMNOLOGY
Hydrology (Phytoplankton, Zooplankton,fish)
Chemistry Hydrology
2nd
ENVIRONMENTAL SCIENCE
Limnology With Ecotoxicology
Economics, Sociology, Political Science, Meteorology, Medicine
REGULATORY ACTION
LOCAL
SEWERAGE & SENEATION
REGULATION
TERTIARY SEWAGE
TREATMENTP-BAN IN DETERGENTS
SO2 EMISSION TARGETS
SUSTAINABLE DEVELOPMENT
ZERO DISCHA RGE
RIO CONVENTION
MONETRAL CONVENTION

Environmental Science/Engineering/ Management Discipline

- **Multidisciplinary or Interdisciplinary**
  - Various disciplines of Science or Engineering or Management
- **Several Professions and Sectors**
  - Industry, Business, Academics and Research, Policy Making, Planning, Judiciary, Implementation/Administration, Journalism; Government/Semi government or Public/ Private Sector/NGOs
- **Preventive Activities, Control Activities, Remedial Activities → Resource Conservation, Sustainable Development; "End of the Pipe" Solutions; Regeneration**

Environmental Engineering and Management Programme

- **CE 602: Mathematics**
  - Basic Preparatory Course
- **EEM 602: Physicochemical Principles and Processes**
  - Fundamental Aspects of Physical, Chemical and Physicochemical Processes
- **EEM 603: Ecological and Biological Principles and Processes**
  - Fundamentals Aspects of Ecological and Biological Processes/Systems
- **EEM 606: Air Pollution and Its Control**
- **ECO 747: Principles of Environmental Economics and Management**

Terms ……..

Environment,

Ecology,

Systems,

Environmental Systems,

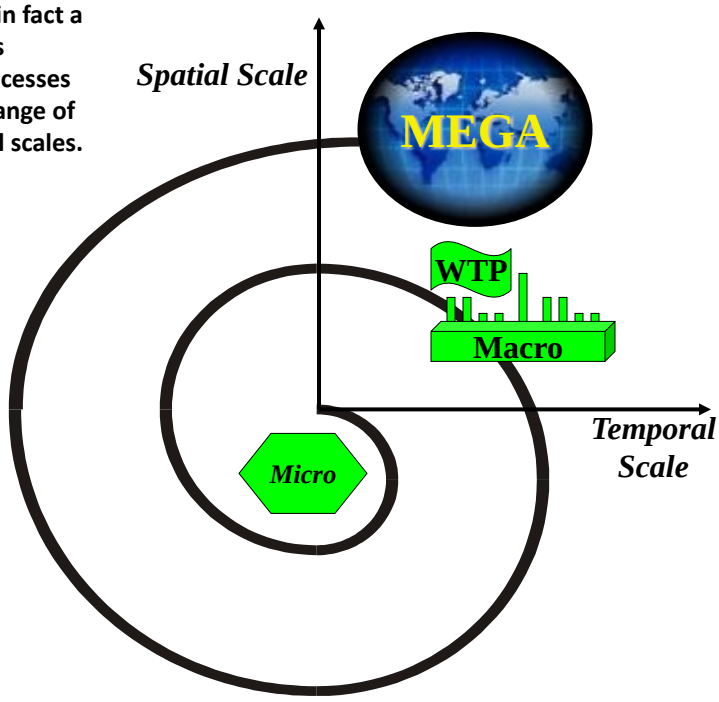
Ecosystems

Environment

Aggregate of surrounding things,
conditions or influences,
especially as affecting or that affects
the existence or development of
someone or something
[LIVING (*Biotic*)]
or
[NON LIVING (*Abiotic*)]

Hardware/ Software →Physical/Nonphysical

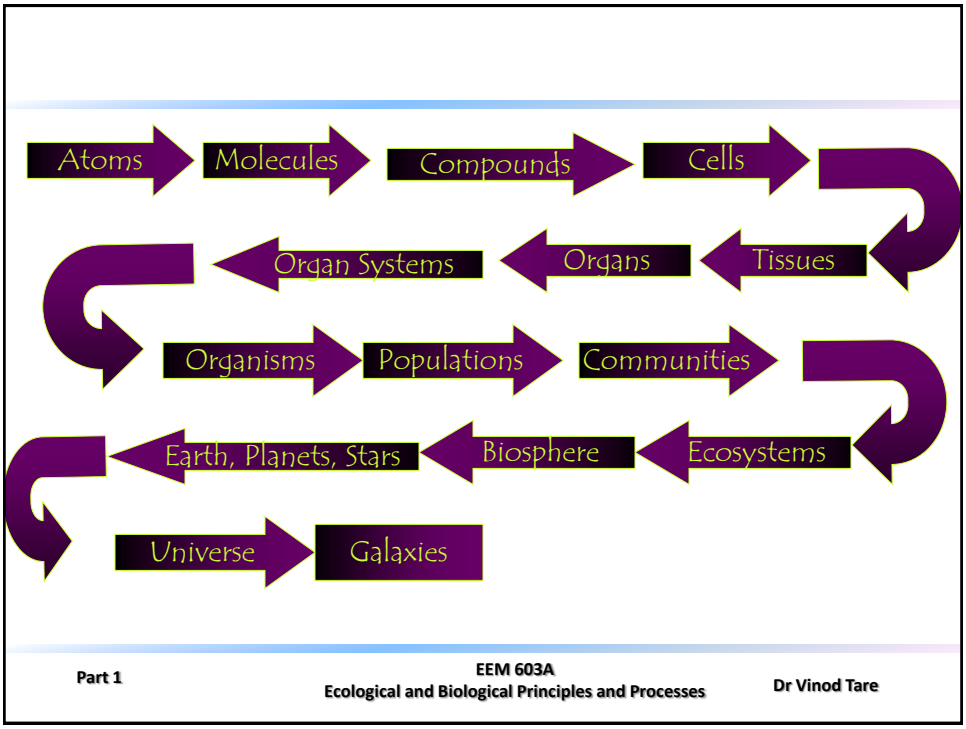
The environment is in fact a continum of systems involving similar processes over a remarkable range of temporal and spatial scales.

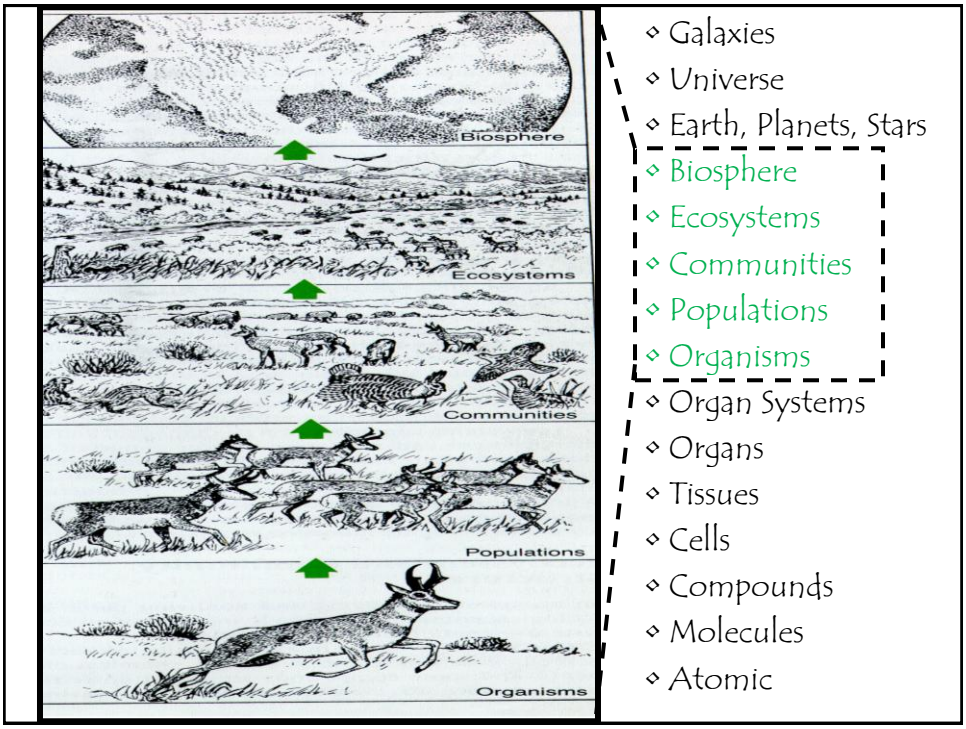


Systems

Collection of objects bonded together in some way so that the collection is more than an independent assemblage of parts

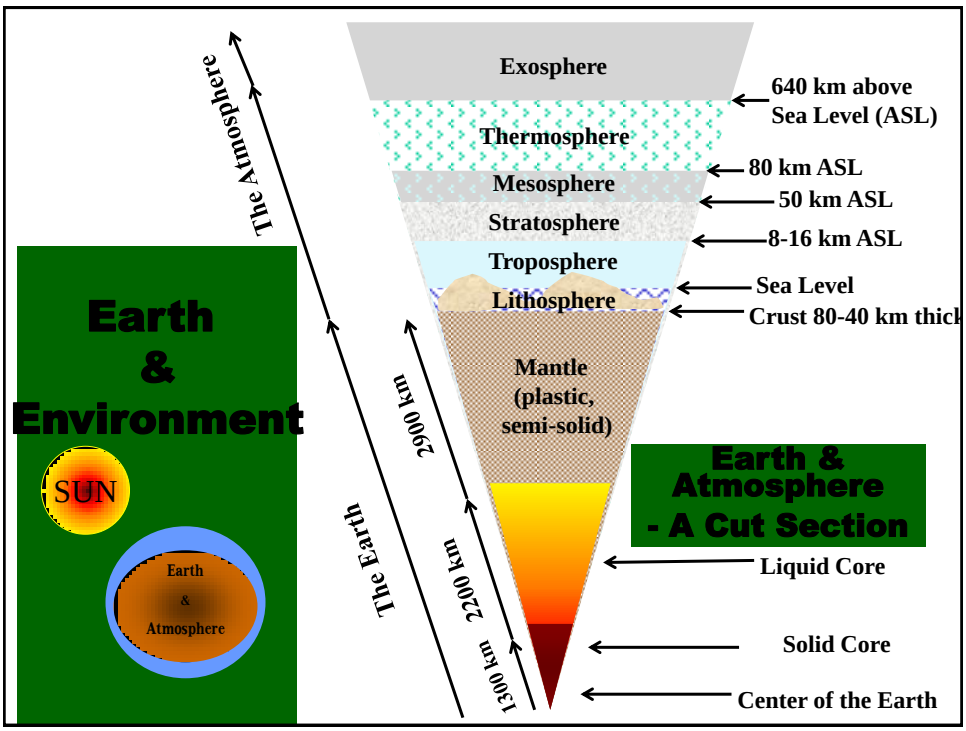
Micro → Macro → Mega Levels (Depending Upon the Boundaries Chosen in a Particular Context)


Atoms
Molecules
Compounds
Cells
Tissues
Organs
Organ Systems
Organisms
Populations
Communities
Ecosystems
Biosphere
Earth, Planets, Stars
Universe
Galaxies
Part 1
EEM 603A
Ecological and Biological Principles and Processes
Dr Vinod Tare


Biosphere
Ecosystems
Communities
Populations
Organisms
Galaxies
Universe
Earth, Planets, Stars
Biosphere
Ecosystems
Communities
Populations
Organisms
Organ Systems
Organs
Tissues
Cells
Compounds
Molecules
Atomic

Ecosystems

Objects consisting of Living (*Biotic Component*) as well as Non-living (*Abiotic Component*) entities



Environment is Complex

However, complexity relates more to innate scales and dimensions than to inherent concepts and principles

This premise serving as incentive, our approach to understanding and explaining the environment and its myriad systems and processes is to:

i) clearly enunciate concepts and related principles.
ii) initiate analyses on scales at which the principles can be classified and applied rigorously.
iii) use simple but accurate experimental and mathematical models to articulate those principles, and.
iv) structure more elaborate models to integrate all relevant principles and thus facilitate their extension to the scale of any system or process of interest.

Chinese Proverb

"To give a man a fish will feed him for a day, but to teach him to fish will feed him for a lifetime"

In the same spirit, any one can solve a problem if given the correct algorithm, but it is the knowledge of how to use concepts and principles to construct correct algorithms that enables one to solve any problem

System Dynamics and Processes

All physical, chemical and biological processes have two dominant characteristics by which they can be commonly identified and quantified

- First → the amount of energy available to make them occur, and the
- Second → the speed or rate at which that energy is exercised to effect change

System Dynamics and Processes

Depends on many things

- The numbers (masses) and the reactivities (or stabilities) of the "Energy Rich" and "Energy Poor" partners of a process
- Pathways available to these partners for effecting their interaction in the context of a given system

System Dynamics and Processes

Specifically, all environmental processes depend upon

1. the availability of energy
2. the means of that energy to be exercised in the timeframe of interest, and
3. a system of such spatial and physical characteristics that it allows the reactant to "communicate" for purpose of reaction.

These are the three tenets of environmental systems

System Dynamics and Processes

For successful description and/or designs of such systems, these tenets must be

1. understood on the basis of fundamental principles
2. represented rigorously in the functional forms, and
3. integrated accurately with the functional forms of other governing principles in appropriate system models

System Dynamics and Processes

In complex systems, empiricism and judgment are required to bridge gaps in absolute knowledge

- It is therefore often necessary that we make assumptions/idealizations in applying above tenets.
- If we understand the functions and constraints embodied in the principles involved, our assumptions will be rational.

Objective

To develop an appreciation of the identifying features and important characteristics of environmental systems and processes that must be factored into their analysis, modeling, and design.

Analysis Approach

- **System Models**
- **Models → tool to describe or represent an object or a process or a phenomenon**
- **Ways/Means**
  - *Physical*
  - *Mathematical*
- **Mathematical Models**
  - *Stochastic*
  - *Deterministic*
- **Approaches**
  - *Theoretical*
  - *Phenomenological*
- **Techniques/Tools → Formulation, solution, calibration, verification and simulation**
  - *Statistical*
  - *Optimization*

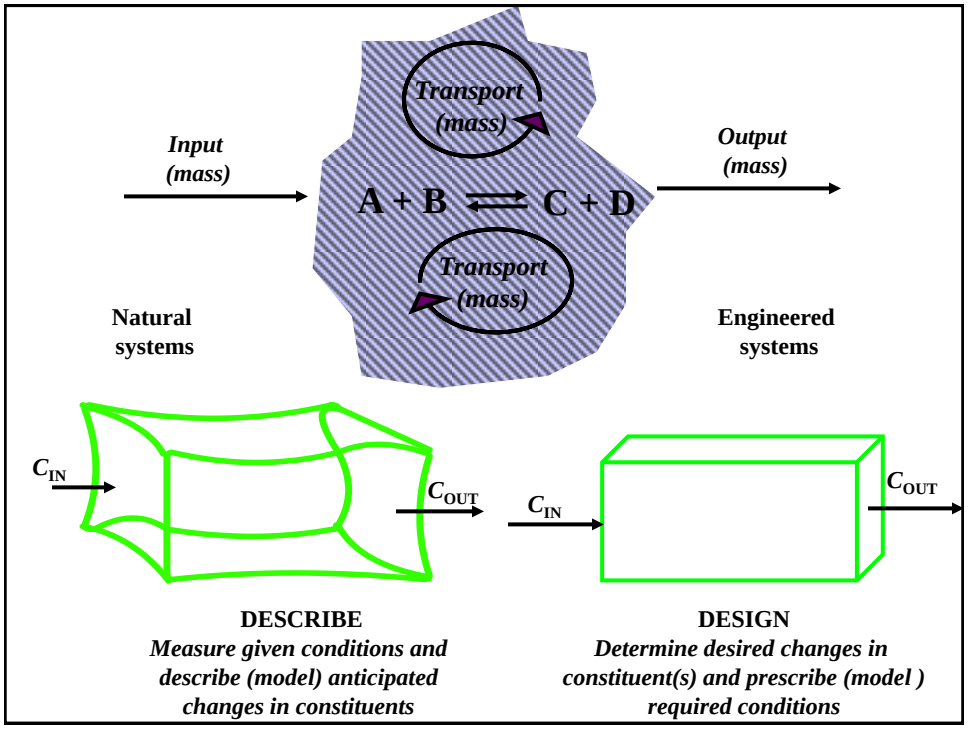
Environmental Systems

- **Broad Categories**
  - *Natural*
  - *Engineered*
- **Scales**
  - *Spatial*
  - *Temporal*

Let us first consider the similarities and differences between two broad categories of environmental systems, natural and engineered, and then address the temporal and spatial scales associated

Environmental Systems

- **Natural**
  - We are concerned with understanding and describing changes
- **Engineered**
  - We are concerned with the selection of conditions required to effectively accomplish specific changes



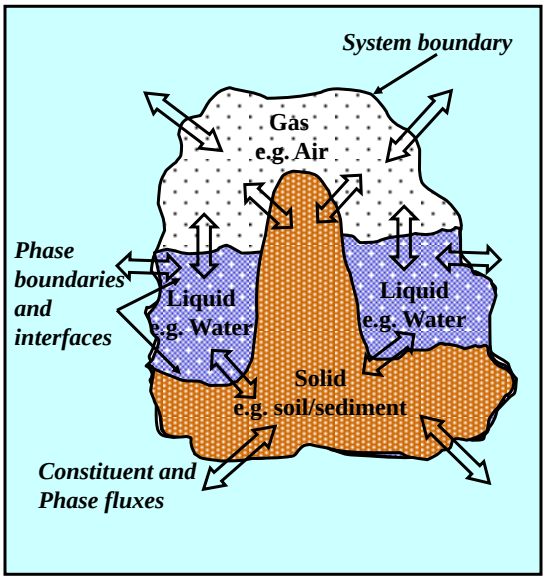
Natural & Engineered Environmental Systems

- While the objectives, information requirements and expected results for natural and engineered systems are usually quite different, the underlying processes and principles of change are essentially the same. Similarly, the methods by which the processes are analyzed and described should be fundamentally the same.
- Successful approaches to system characterizations, process analyses, and quantification of components and constituent changes must in every instance, be based on the same principles and precepts of process dynamics.

Character and Scale

At the most elementary level we distinguish the character of a system on the basis of its scale. By character we mean the properties of a system and the nature of changes that occur within it. By scale we mean the size (spatial scale) of the system and the time (temporal scale) that together determine the boundaries within and over which the changes of interest occur

Generalized Multiphase System of Gaseous, Liquid and Solid Phases



It is important to note, however, that the composition of each phase depicted in figure above changes as a result of phase and constituent mass reductions and additions that may occur not only by reactions among constituents within the boundaries of phase, but also by movement of mass across its phase boundaries and accumulations or depletions within interfaces at those phase boundaries.

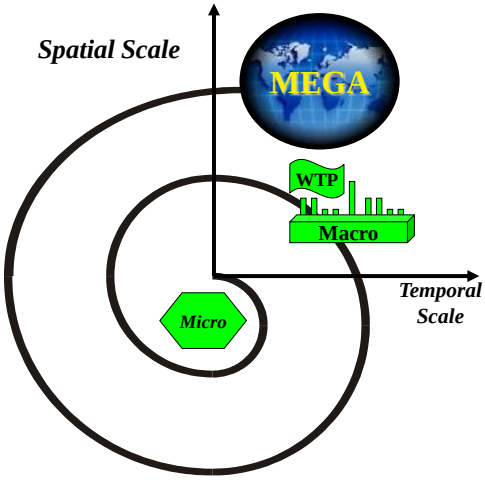
Environmental Systems - Analysis Approach

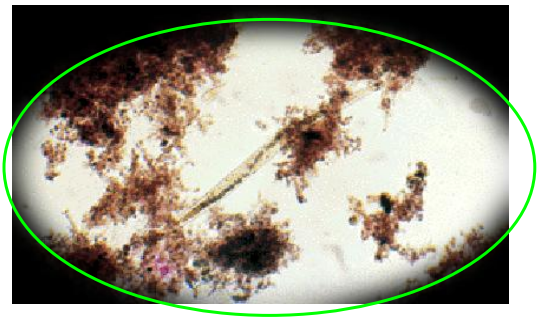
- All systems are comprised by subsystems; mega-scale systems by macro-scale systems, and macro-scale systems by micro-scale systems. This is why many processes can be influenced at the macroscopic scale by similar microscopic mass transfer phenomenon.
- The most fundamental analysis of any system has its origins ultimately at the molecular level, and must provide that there is a continuity of principles derived from this scale to the full scale of the system.

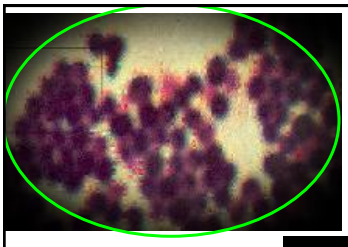
Environmental Systems -Analysis Approach

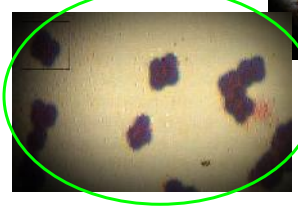
- Any analysis of a process for purpose of description or design must couple descriptions of phenomena at the appropriate micro scale with those of phenomena at the macro scale or mega scales.
- It is essential that we appreciate the role of micro scale process dynamics and understand how to incorporate information on processes at this scale in the characterization, analysis, interpretation, and design of environmental macro scale systems.

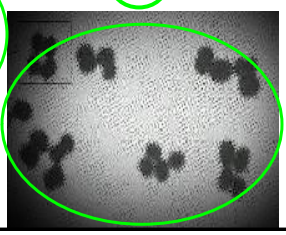
The environment is in fact a continuum of systems involving similar processes over a remarkable range of temporal and spatial scales.

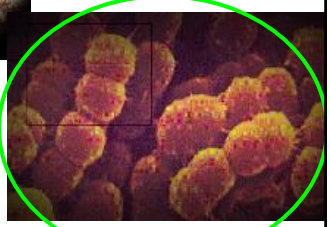


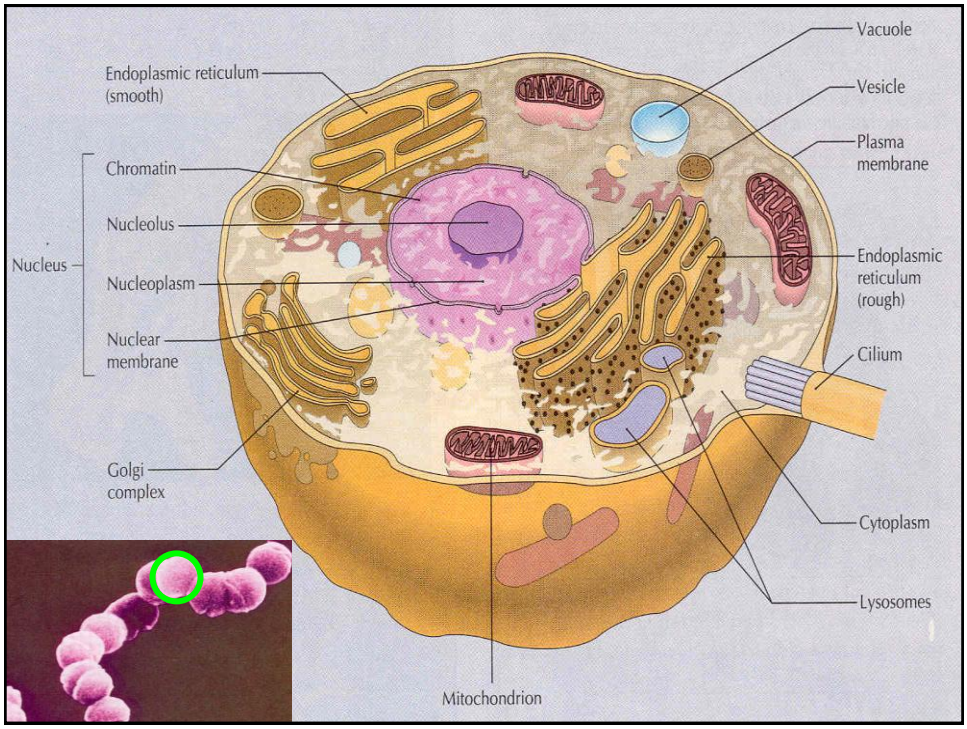











Vacuole
Endoplasmic reticulum (smooth)
Vesicle
Plasma membrane
Chromatin
Nucleolus
Nucleus
Nucleoplasm
Endoplasmic reticulum (rough)
Nuclear membrane
Cilium
Golgi complex
Cytoplasm
Lysosomes
Mitochondrion